

NUMMULITES (FORAMINIFERA) FROM THE UPPER EOCENE KOPILI FORMATION OF ASSAM, INDIA

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ABSTRACT. Four species of *Nummulites* are described and illustrated from the Kopili Formation, Garo Hills, Assam, India. This is the first account of the genus *Nummulites* from the Upper Eocene *Pellatispira*-bearing horizon in the Indian region.

OUTCROPS of marine Upper Eocene rocks with larger foraminifera are known to occur in three areas in the India-Pakistan region (Samanta 1968, fig. 1): Surat-Broach in Western India (Rao 1941), the Sulaiman Range in West Pakistan (Eames 1952) and Assam in Eastern India (Nagappa 1951, Samanta 1965). *Nummulites* has been reported to occur in association with the typical Upper Eocene genus *Pellatispira* in all three areas but so far there is no published account of the genus from this horizon.

In Assam the Kopili Formation contains a rich Upper Eocene larger foraminiferal assemblage including such stratigraphically important genera as *Asterocyclina*, *Discocyclina*, *Nummulites*, and *Pellatispira*. An investigation of the larger foraminifera of the Kopili Formation in the Garo Hills has been carried out by the writer and an account of the genus *Nummulites* is given in the present paper.

KOPILI FORMATION

Evans (1932, pp. 173-5) first called this unit the Kopili alternations 'Stage' and sometimes Kopili 'Stage'. Later workers have changed the name to Kopili Formation, since by original designation it is basically a rock unit. In the type section (Kopili River section of the Kopili-Khorungma region) the succession is reported to be about 450 m. thick and consists of alternations of sandstone, mudstone, shales, carbonaceous rocks, and shell-bearing sandstone. It conformably overlies the Sylhet Limestone and is apparently conformably overlain by the Barail group of rocks. The formation outcrops along the southern fringe of the Shillong Plateau, from the Garo Hills in the west to the Mikir Hills in the east.

In the Garo Hills the Kopili Formation is best exposed in the Simsang River section between Siju Artheika (90° 41' E., 25° 20' N.) and Matmagitik (90° 40' E., 25° 18' N.). It conformably overlies the Siju Limestone and is apparently conformably overlain by Barail-equivalent rocks (Samanta 1968, p. 128, table 1). The lower part of the formation is richly fossiliferous and contains abundant larger foraminifera, including such stratigraphically important genera as *Asterocyclina*, *Discocyclina*, *Nummulites*, and *Pellatispira*. Of these, *Discocyclina* is the most abundant. Because of their much larger size in comparison to other larger foraminifera, discocyclines constitute the most conspicuous element of the foraminiferal fauna. *Nummulites* is represented by small to medium sized striate and reticulate forms and occurs in almost all foraminiferal samples. In contrast

to *Discocyclina* and *Nummulites*, *Asterocyclina* and *Pellatispira* occur in fewer samples and are much less abundant in numbers of individuals.

The following larger foraminifera are identified from the Kopili Formation, Garo Hills (see also Samanta 1968, p. 129, table 2):

<i>Asterocyclina matanzensis</i> Cole	<i>D. sowerbyi</i> Nuttall
<i>Discocyclina archiaci</i> (Schlumberger)	<i>D. sp. cf. D. trabayensis</i> Neumann
<i>D. assamica</i> Samanta	<i>Nummulites chavannesi</i> de la Harpe
<i>D. augustae</i> Weijden	<i>N. sp. aff. N. chavannesi</i> de la Harpe
<i>D. dispansa</i> (Sowerby)	<i>N. fabianii</i> (Prever)
<i>D. eamesi</i> Samanta	<i>N. pengaronensis</i> Verbeek
<i>D. javana</i> (Verbeek)	<i>Pellatispira inflata</i> Umbgrove
<i>D. omphalus</i> (Fritsch)	<i>P. sp. cf. P. irregularis</i> Umbgrove
<i>D. pygmaea</i> Henrici	<i>P. madaraszi</i> (Hantken)
<i>D. sella</i> (d'Archiac)	<i>P. sp. cf. P. orbitoidea</i> (Provale)

Of these, *D. augustae*, *D. sella*, *N. chavannesi*, *N. fabianii*, and *P. madaraszi* are recorded from the Priabonian of North Italy, while *A. matanzensis*, *D. javana*, *D. omphalus*, *D. pygmaea*, *D. sella*, *N. pengaronensis*, and the four species of *Pellatispira* are abundantly represented in the T b of the Indonesian region. The larger foraminiferal assemblage, therefore, indicates a definite Upper Eocene age for the lower part of the Kopili Formation.

Material. The material was collected from five localities in the Garo Hills, previously described (Samanta 1965, p. 416, text-fig. 3). All the four species of *Nummulites* are represented by sufficient material. Presence of free specimens permits a detailed study of these forms. Table 1 shows the distribution of the species in the Garo Hills.

TABLE 1. *Distribution of Nummulites in the Kopili Formation, Garo Hills, Assam*

Species	Localities				
	Sa	Rn	Rgt	N	K
<i>Nummulites chavannesi</i> de la Harpe					X
<i>N. sp. aff. N. chavannesi</i> de la Harpe		X		X	X
<i>N. fabianii</i> (Prever)	X	X			X
<i>N. pengaronensis</i> Verbeek	X	X	X	X	X

Acknowledgements. The author is indebted to Dr. J. R. Haynes for critically reading the manuscript; Dr. F. E. Eames for helpful discussions; Professors H. Hagn and E. Montanaro Gallitelli for comparative material; Drs. F. Bieda and V. Roveda for literature; Professor Alan Wood for providing facilities in his Department; and Mr. H. Williams for help in preparing the plates.

SYSTEMATIC PALAEOLOGY

Family NUMMULITIDAE de Blainville 1825 Subfamily NUMMULITINAE de Blainville 1825 Genus NUMMULITES Lamarck 1801

Nummulites chavannesi de la Harpe

Plate 128, figs. 11, 12; Plate 129, figs. 9-14; text-fig. 1

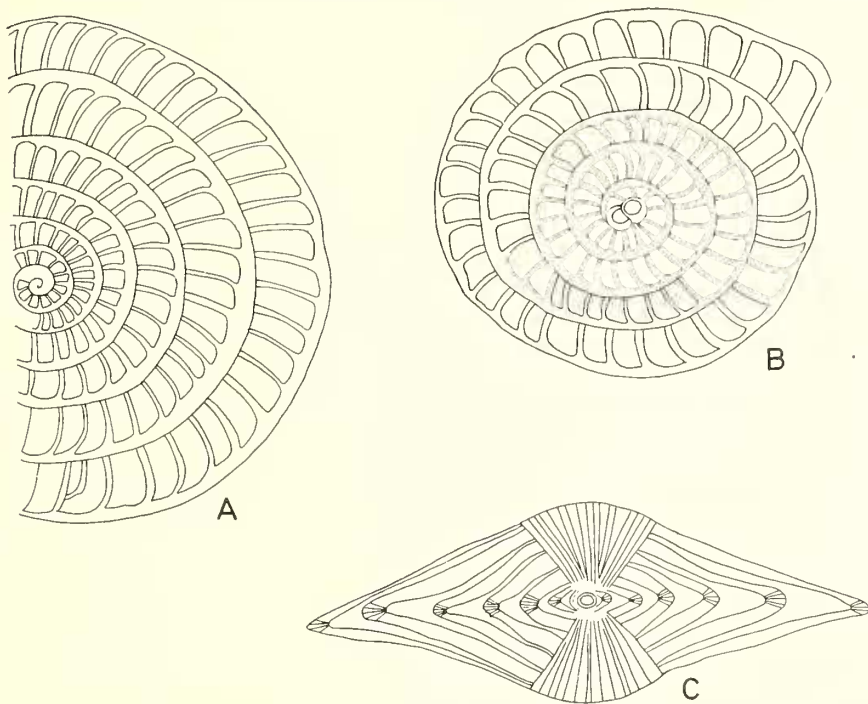
1877 *Nummulites chavannesi* de la Harpe, p. 232 (*nom. nud.*).

1883a *Nummulites bouillei* var. *ritimeyeri* de la Harpe, pl. 6, figs. 5-11.

1883a *Nummulites chavannesi* de la Harpe, pl. 6, figs. 22-41.

1883b *Nummulites ritimeyeri* de la Harpe, pp. 162, 163, pl. 30, figs. 9-11.

- 1883b *Nummulites chavannesi* de la Harpe; de la Harpe, pp. 163, 164, pl. 30, figs. 12–18.
 1911b *Nummulites chavannesi* de la Harpe; Boussac, pp. 37, 38.
 1934 *Nummulites* cf. *chavannesi* de la Harpe; Flandrin, pp. 254, 255, pl. 14, figs. 15, 16.
 1934 *Nummulites rütimeyeri* de la Harpe; Flandrin, p. 254, pl. 14, fig. 17.
 1938 *Nummulites rütimeyeri* de la Harpe; Flandrin, pp. 34, 35, pl. 3, figs. 9, 10.
 1951 *Nummulites rütimeyeri* de la Harpe; Daci, pp. 209, 210, pl. 2, figs. 7, 8.
 1951 *Nummulites chavannesi* de la Harpe; Daci, pp. 210, 211, pl. 2, fig. 9.
 1957 *Nummulites chavannesi* de la Harpe; Bieda, pp. 46, 47, pl. 4, figs. 8, 9.
 1960 *Nummulites chavannesi* de la Harpe; Hagn, p. 70, pl. 1, fig. 2; pl. 2, figs. 4, 5.
 1961 *Nummulites chavannesi* de la Harpe; Roveda, pp. 177–81, pl. 14, figs. 1–8.
 1963a *Nummulites chavannesi* de la Harpe; Bieda, pp. 71, 72, 186, pl. 6, figs. 5–7; pl. 7, figs. 1–3.



TEXT-FIG. 1. *Nummulites chavannesi* de la Harpe. A, Part of the equatorial section of a microspheric specimen. $\times 20$ approx. B, Equatorial section of a megalospheric specimen, $\times 25$ approx. C, Axial section of a megalospheric specimen, $\times 25$ approx. All from locality K.

Material. Megalospheric form—25 specimens examined externally, 5 specimens studied in equatorial section, and 5 in axial section. Microspheric form—6 specimens examined externally, 3 specimens studied in equatorial section, and 2 in axial section.

Description. *Megalospheric form.* Test small, lenticular, with slightly elevated polar region surrounded by sloping peripheral part; margin acute. Surface ornamented with well-developed polar pustules from which thin, straight to gently curved septal filaments radiate. Diameter of test varies from 1.9 to 3.4 mm., thickness from 0.9 to 1.4 mm., ratio of diameter to thickness from 2.2 to 2.7, and diameter of polar pustules from 0.4 to 0.6 mm.

About $4\frac{1}{2}$ to 6 regularly coiled whorls open rapidly. Spiral lamina thin and in outer

whorls height of spiral cavity about 4 to 6 times thickness of spiral lamina. Septa nearly perpendicular to spiral lamina, straight with sharp curvature near distal end. About 8–11 septa occur in 1st whorl; 15–20 in 2nd; 19–28 in 3rd; 24–9 in 4th; and 28–32 in 5th.

Small, subcircular first chamber followed by subequal, reniform second chamber. Separating wall either straight or curved outwards. Diameters of first chamber vary from 0.055×0.050 mm. to 0.095×0.075 mm. and those of second chamber from 0.055×0.045 mm. to 0.100×0.060 mm. Distance across both chambers varies from 0.105 to 0.180 mm. Equatorial chambers quadrate in shape and about twice as high as long.

In axial section first chamber circular and about 0.05 mm. in height. Chamber cavity triangular in shape. Alar prolongations wide open. Marginal cord distinct. Wedge-shaped polar plugs always very conspicuous and about 0.6 mm. in diameter near surface.

Microspheric form. Test small with well-developed, slightly elevated polar pustules; margin acute. Septal filaments thin, radiate, nearly straight. Diameter of test varies from 3.8 to 5.0 mm., thickness from 1.8 to 2.0 mm., ratio of diameter to thickness from 2.1 to 2.4 mm., and diameter of polar pustules from 0.8 to 1.0 mm.

There are about 9 whorls in diameter of 4.2 mm. Whorls regularly coiled and open rather rapidly. In outer whorls height of spiral cavity about 3 times thickness of spiral lamina. Septa nearly perpendicular and straight with sharp curvature at top. Chambers quadrate, about 2 to 3 times higher than long.

In axial sections alar prolongations wide open. Marginal cord distinct. Well-developed polar plugs wedge-shaped, about 1.0 mm. in diameter near surface.

Remarks. The presence of well-defined polar pustules, high equatorial chambers between almost straight septa, and wide alar prolongations distinguish this species from the associated nummulites in the Kopili Formation. The Assam specimens have been compared with European material, provided by Professor H. Hagn. They are closely similar to the Priabonian material described and illustrated by Roveda (1961).

Distribution. *N. chavannesesi* has been reported from Italy, Spain, France, Switzerland, Poland, Hungary, Albania, Turkey, Algeria, Egypt, and Somaliland. Its known range is from Upper Eocene to Oligocene.

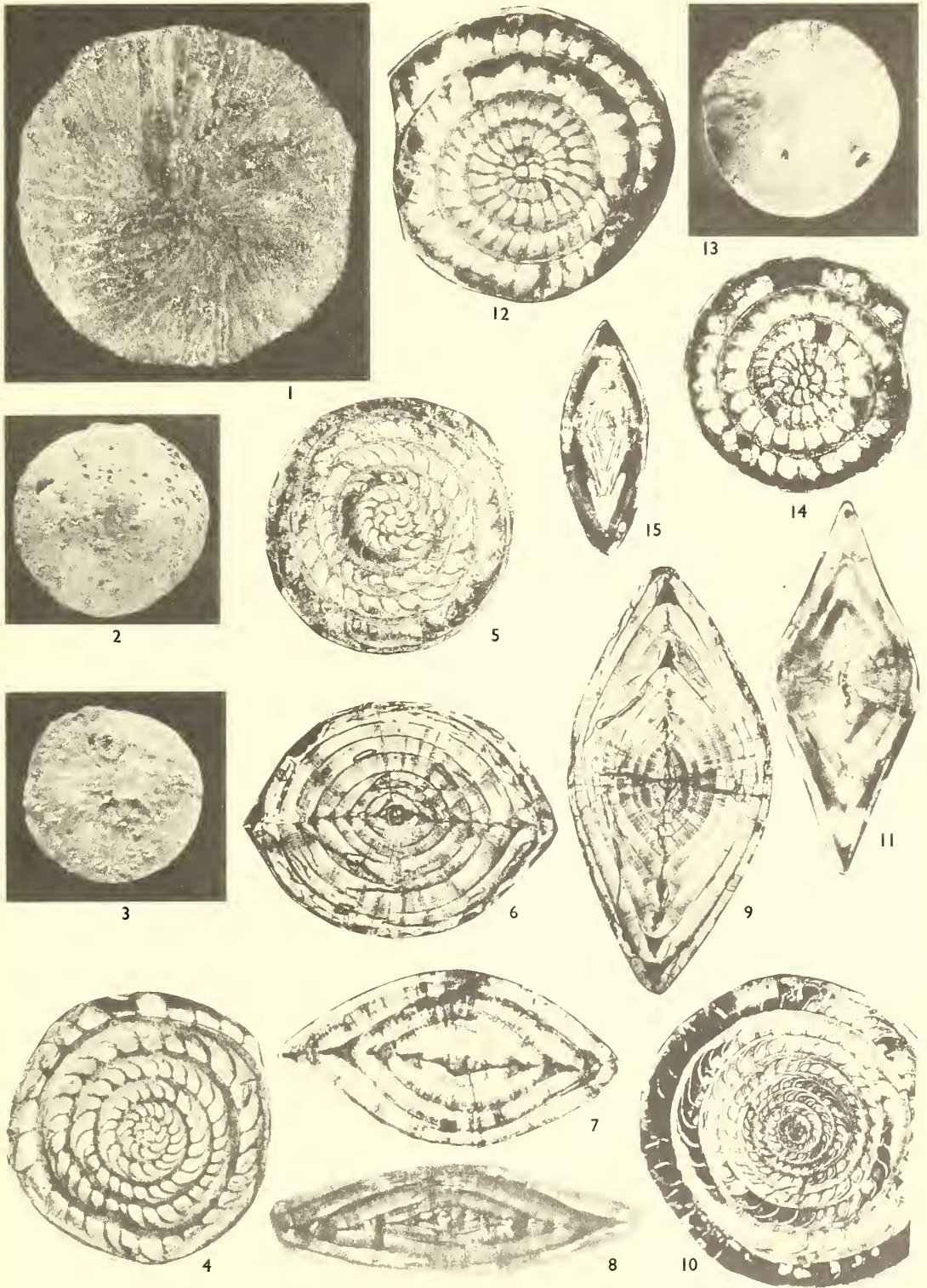
In the Garo Hills *N. chavannesesi* occurs only in the Upper Eocene Kopili Formation (Table 1). There is no report of its occurrence in the other Upper Eocene localities in India and adjacent countries. The present record of *N. chavannesesi* extends its geographic distribution considerably.

EXPLANATION OF PLATE 128

Figs. 1–10. *Nummulites pengatonensis* Verbeek. 1, External view of microspheric specimen, $\times 6$. 2, 3, External views of megalospheric specimens; 2, inflated variety, $\times 6$; 3, compressed lenticular variety, $\times 9$. 4, 5, Equatorial sections of megalospheric specimens, $\times 15$; 4, inflated variety; 5, lenticular variety. 6–8, Axial sections of megalospheric specimens showing variation in transverse views of tests; 6, $\times 15$; 7, 8, $\times 21$. 9, Axial section of microspheric specimen, $\times 9$. 10, Equatorial section of microspheric specimen, $\times 9$. 1, 3, 8, 10, from locality Sa; 2, 7, from locality K; 4, 5, from locality Rn; 6, 9, from locality N (see Samanta 1965, p. 416).

Figs. 11, 12. *Nummulites chavannesesi* de la Harpe. 11, Axial section of megalospheric specimen, $\times 21$. 12, Equatorial section of megalospheric specimen, $\times 21$. Both from locality K.

Figs. 13–15. *Nummulites* sp. aff. *N. chavannesesi* de la Harpe. 13, External view of megalospheric specimen, $\times 15$. 14, Equatorial section of megalospheric specimen, $\times 21$. 15, Axial section of megalospheric specimen, $\times 21$. All from locality K.



SAMANTA, Upper Eocene *Nummulites*

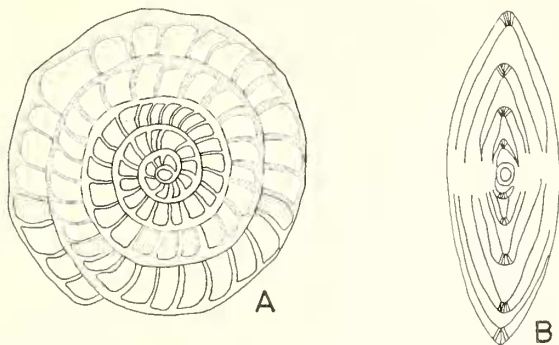
Nummulites sp. aff. *N. chavannesi* de la Harpe

Plate 128, figs. 13–15; text-fig. 2

Material. Only megalospheric specimens were observed. 15 specimens examined externally, 5 specimens studied in equatorial section, and 2 in axial section.

Description. *Megalospheric form.* Test very small, lenticular, with acute margin. Septal filaments thin and radial. Diameter of test varies from 1.6 to 2.0 mm., thickness from 0.56 to 0.80 mm., and ratio of diameter to thickness from 2.0 to 3.4.

Spire is regular with about $4\frac{1}{2}$ to $5\frac{1}{2}$ whorls increasing regularly in height. Spiral lamina thin, about $\frac{1}{5}$ height of spiral cavity in thickness. Septa are perpendicular to wall and



TEXT-FIG. 2. *Nummulites* sp. aff. *N. chavannesi* de la Harpe (megalospheric form.) A, Equatorial section. B, Axial section. Both from locality K, $\times 25$ approx.

nearly straight with curvature at top. About 8–10 septa occur in 1st whorl; 15–18 in 2nd; 19–25 in 3rd; 24–6 in 4th; and 24–30 in 5th.

Subcircular first chamber followed by subequal, crescentic second chamber. Separating wall gently curved outwards. Diameters of first chamber vary from 0.05×0.03 mm. to 0.08×0.07 mm.; those of second chamber from 0.055×0.035 mm. to 0.10×0.055 mm. Distance across both chambers varies from 0.09 to 0.15 mm. Equatorial chambers quadrate and higher than long.

In axial section first chamber circular, about 0.06 mm. in height. Alar prolongations wide open. Marginal cord distinct.

Remarks. The present specimens are closely similar to *N. chavannesi* in internal characters, but can easily be distinguished from the latter by the shape of the test and the absence of polar pustules. They are provisionally identified as *N. sp. aff. N. chavannesi*.

Distribution. The species occur in localities Rn, N, and K in the Garo Hills (Samanta 1965, p. 416). The presence of similar forms has also been noticed by the writer in the Upper Eocene of Surat-Broach, Western India.

Nummulites fabianii (Prever)

Plate 129, figs. 1–8; text-fig. 3, 4

1905 *Bruguieria fabianii* Prever *in litt.*; Fabiani, pp. 1805, 1811, 1824.1905 *Bruguieria sub-fabianii* Prever *in litt.*; Fabiani, pp. 1811, 1824.

- 1906 *Nunuulites fabianii* (Prever in Fabiani); Boussac, pp. 88–90, pl. 1, figs. 1–5, 7–9; pl. 3, fig. 6.
- 1911a *Nununulites fabiauui* Prever in Fabiani; Boussac, pp. 40, 72, pl. 10, figs. 1, 2, 28; pl. 17, figs. 8, 11, 13.
- 1911b *Nununulites fabiauui* Prever in Fabiani; Boussac, pp. 79–84, pl. 1, figs. 6, 13; pl. 4, figs. 9, 10.
- 1928 *Nunuulites fabianii* Prever; de Cizancourt, p. 294, pl. 2, fig. 10.
- 1930 *Nununulites fabiauui* Prever; de Cizancourt, pp. 209, 210, pl. 22, figs. 4, 7; pl. 23, fig. 5.
- 1934 *Nununulites fabiauui* Prever; Flandrin, p. 259, pl. 1, fig. 20.
- 1951 *Nunuulites fabianii* Prever; Daci, pp. 221, 222, pl. 3, figs. 1, 2.
- 1951 *Nunuulites subfabianii* Prever; Daci, pp. 222–4, pl. 3, figs. 4–7.
- 1957 *Nununulites fabianii* Prever; Bieda, p. 30, pl. 5, fig. 5.
- 1959 *Nununulites retiatius* Roveda, pp. 201–7, pl. 1, figs. 1–11.
- 1960 *Nunuulites fabiauui* (Prever); Hagn, p. 149, pl. 2, figs. 2, 3, 7.
- 1961 *Nununulites fabianii* (Prever); Roveda, pp. 161–9, pl. 15, figs. 15, 16; pl. 17, figs. 8, 9; pl. 18, figs. 4, 5; pl. 19, figs. 1, 6–8, 14–16.
- 1963a *Nununulites fabiauui* Prever; Bieda, pp. 101–4, 195, 196, pl. 15, fig. 9; pl. 16, figs. 1–4.
- 1963b *Nununulites fabiauui* Prever; Bieda, pp. 201–4, 214–15, pl. 13, figs. 3, 4.
- 1965 *Nununulites fabiauui* Prever; Bozorgnia and Kalantari, pp. 17, 18; pl. 20, figs. 1–7.

Material. Megalospheric form—20 specimens examined externally, 5 studied in equatorial section, and 7 in axial section. Microspheric form—10 specimens examined externally, 4 studied in equatorial section, and 1 in axial section.

Description. Megalospheric form. Test small, lenticular, with subacute margin. Surface ornamented with spirally arranged rectangular meshes produced by intersections of radial filaments with raised spiral line. Spirally arranged granules joined together by 'transverse lamina' produce raised spiral line. In some specimens granules cluster at poles to form polar pustules. Diameter of test varies from 1.8 to 3.0 mm., thickness from 1.25 to 1.85 mm., and ratio of diameter to thickness from 1.4 to 1.9.

About 5 to $6\frac{1}{2}$ regularly coiled whorls occur, increasing slowly in height. Spiral lamina thick, and in some inner whorls may be as thick as height of spiral cavity. Near periphery height of spiral cavity about 2 to 3 times thickness of spiral lamina. Septa slightly inclined to spiral wall, straight to gently curved in their course. About 6–7 septa occur in 1st whorl; 9–13 in 2nd; 12–16 in 3rd; 15–20 in 4th; and 16–22 in 5th.

Subcircular first chamber followed by smaller, semicircular to reniform second chamber. Separating wall either straight or curved outwards. Diameters of first chamber vary from 0.130×0.095 mm. to 0.20×0.20 mm.; those of second chamber from 0.10×0.05 mm. to 0.175×0.095 mm. Distance across both chambers varies from 0.16 to 0.28 mm. Chambers quadrate in shape. Near centre, chambers almost as long as high, but in ontogeny chambers become considerably longer, so that in outer whorls chambers become twice as long as high.

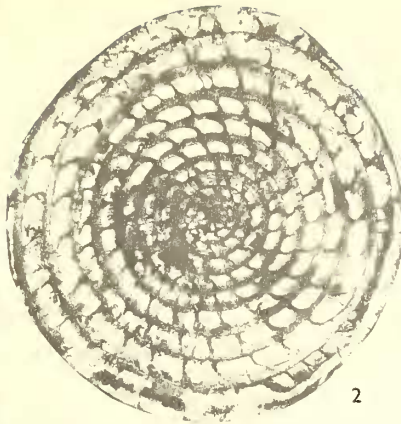
EXPLANATION OF PLATE 129

Figs. 1–8. *Nununulites fabiauui* (Prever). 1, External view of microspheric specimen, $\times 6$. 2, 3, Equatorial sections of microspheric specimens, $\times 9$. 4, External view of megalospheric specimen, $\times 15$. 5, 6, Axial sections of megalospheric specimens, $\times 21$. 7, Equatorial section of megalospheric specimen, $\times 15$. 8, Axial section of microspheric specimen, $\times 7.5$. All from locality Rn (see Samanta 1965, p. 416).

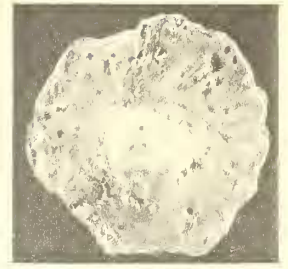
Figs. 9–14. *Nunuulites chavaimesi* de la Harpe. 9, External view of microspheric specimen, $\times 6$. 10, 11, External views of megalospheric specimens, $\times 12$. 12, Axial section of megalospheric specimen, $\times 21$. 13, Equatorial section of megalospheric specimen, $\times 21$. 14, Equatorial section of microspheric specimen, $\times 15$. All from locality K.



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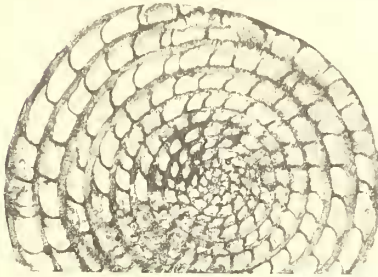
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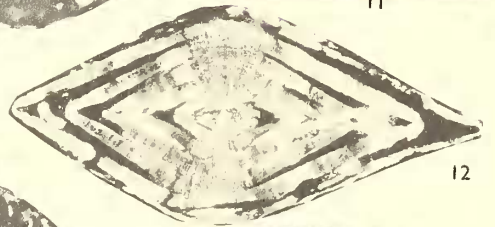
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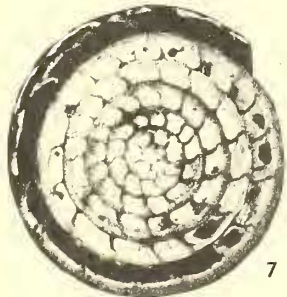
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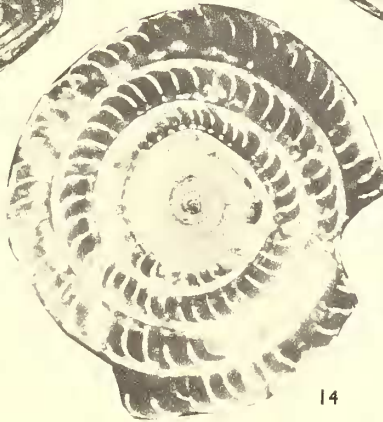
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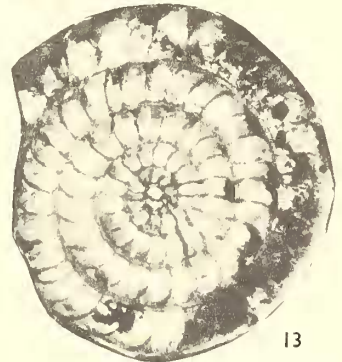
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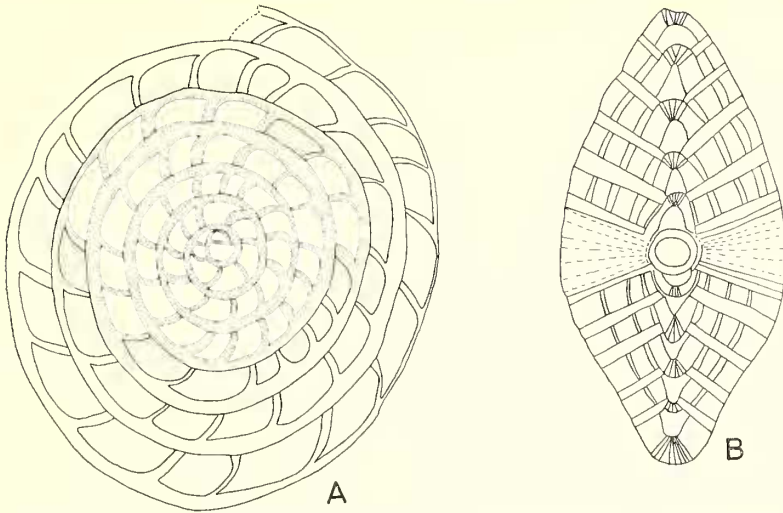
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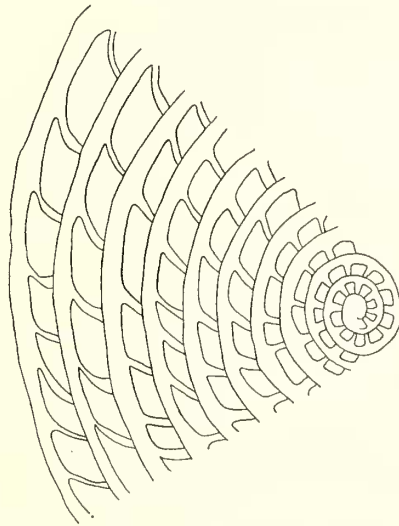
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TEXT-FIG. 3. *Nummulites fabianii* (Prever) (megalospheric form). A, Equatorial section. B, Axial section. Both from locality Rn, $\times 25$ approx.



TEXT-FIG. 4. *Nummulites fabianii* (Prever). Part of the equatorial section of a microspheric specimen from locality Rn, $\times 18$ approx.

In axial section first chamber circular, about 0.10 to 0.13 mm. in height. Spiral lamina rather thick. There may be reduction in thickness of spiral lamina at periphery. Alar prolongations narrow to moderately open. Marginal cord distinct. Pillars well-developed, start from marginal cord of each whorl, and of uniform thickness throughout length. At poles, pillars cluster together to form polar plugs. Diameter of pillars varies from 0.050 to 0.075 mm. and polar plugs from 0.25 to 0.50 mm.

Microspheric form. Test medium-sized, lenticular, with subacute margin. Surface of

test ornamented with thin, reticulate septal filaments. In young individuals rectangular meshes are discernible but in adult specimens branching filaments produce complex network. Diameter of test varies from 5.1 to 8.4 mm., thickness from 2.7 to 4.2 mm., and ratio of diameter to thickness from 1.9 to 2.2.

In equatorial section about 9 to 13 whorls occur, coiled regularly and increasing slowly in height during ontogeny. Spiral lamina rather thick. In adult whorls height of spiral cavity usually greater than thickness of spiral lamina. Septa inclined to whorl wall, and straight to gently curved in their course. Equatorial chambers longer than high, and in outer whorls 3 to 4 times as long as high.

In axial section, alar prolongations narrow to moderately open. Marginal cord distinct. Pillars moderately developed. Each pillar starts from marginal cord and extends up to surface. Diameter of pillars varies from 0.05 to 0.15 mm. In polar region pillars cluster together to form polar plug-like structures about 0.8 mm. in diameter near surface.

Remarks. Both in external and internal features the present form is distinctive. The reticulate ornamentation, the long equatorial chambers, and the pillared axial section enables the species to be distinguished from the associated nummulites in the Kopili Formation. The Assam specimens were compared with those of *N. fabianii* from North Italy provided by Professor Montanaro-Gallitelli.

Because of their distinctive morphological features and wide geographic distribution in the rocks of Upper Eocene to Oligocene age, the reticulate *Nummulites* have received particular attention and several species have been described. But at present there is considerable difference of opinion about the validity of a number of these forms (see Eames *et al.* 1959; Bieda 1963*b*); consequently, application of reticulate *Nummulites* species in the finer biostratigraphic zonation of Upper Eocene–Oligocene rocks is lacking.

Distribution. *N. fabianii* is one of the most widely distributed representatives of the genus, reported from the Upper Eocene of Italy, Spain, France, Switzerland, Poland, Hungary, Albania, Rhodes Island, Turkey, Morocco, Algeria, Tunisia, Libya, Egypt, and Iran.

In the Garo Hills *N. fabianii* occurs in the Kopili Formation at localities Sa, Rn, and K (Table 1). It occurs also in two other Upper Eocene localities in the Indian region; in the Sulaiman Range its presence has been noted by Bayliss (1961), while the writer has observed it in Surat-Broach in association with *Pellatispira* spp., etc.

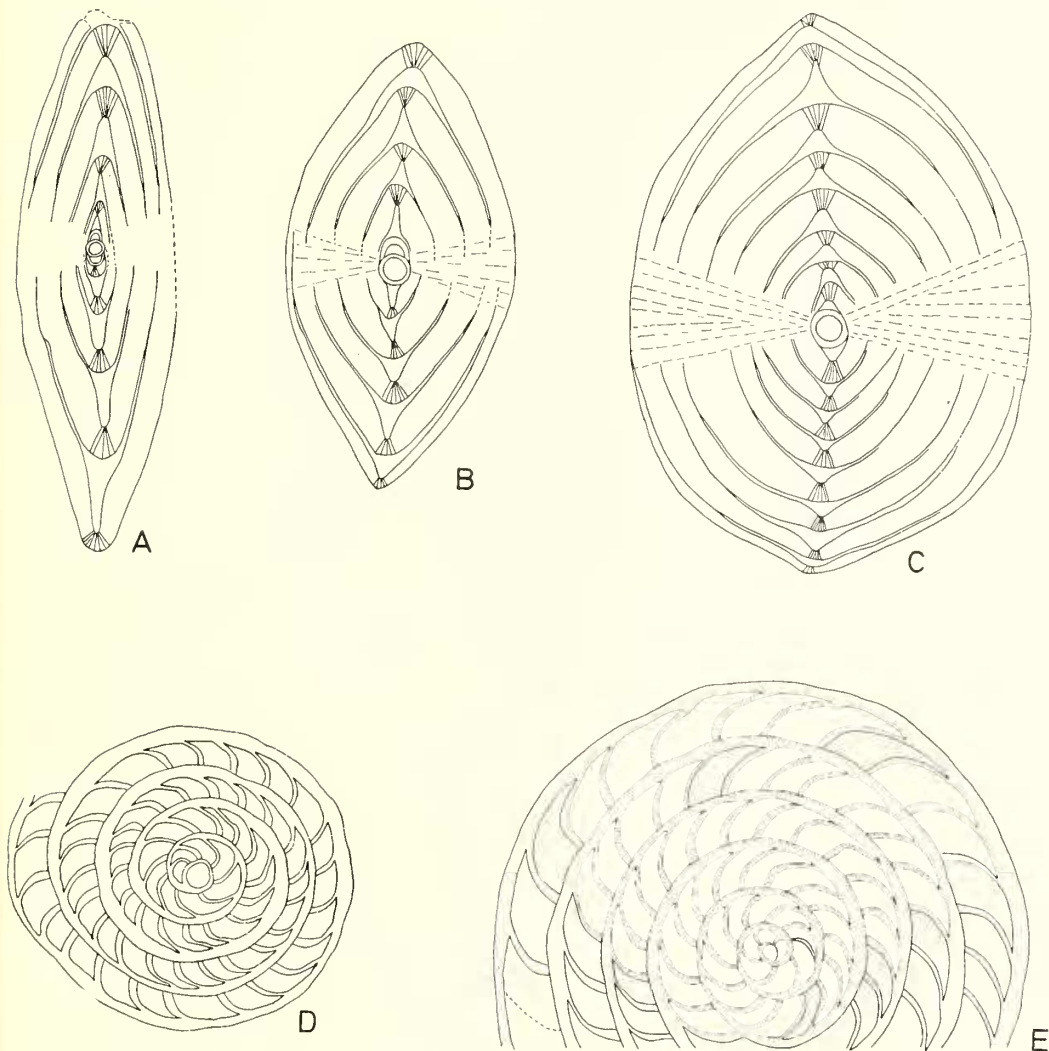
There is no authentic record of reticulate *Nummulites* from the Upper Eocene of the Malayan Archipelago (Cole 1963, Adams 1965). The only report of an occurrence in association with a typical Upper Eocene assemblage from this region was that by Cole (Cloud and Cole 1953, p. 323) who later (1963, pp. E4, E14) postulated that the Upper Eocene species in the assemblage are reworked specimens and that reticulate *Nummulites* do not occur in the Eocene of the Malayan Archipelago. Thus, Assam is the easternmost locality with *N. fabianii*.

Nummulites pengaronensis Verbeek

Plate 128, figs. 1–10; text-figs. 5, 6

- 1871 *Nummulites pengaronensis* Verbeek, pp. 3–6, pl. 1, figs. 1a–k.
 1892 *Nummulites nanggoelani* Verbeek, pp. 116, 118.
 1896 *Nummulites nanggoelani* Verbeek; Verbeek and Fennema, p. 1152, pl. 8, figs. 111–13.
 1896 *Nummulites pengaronensis* Verbeek; Verbeek and Fennema, pp. 1153, 1154.
 1912 *Nummulites pengaronensis* Verbeek; Douvillé, pp. 284, 285, pl. 24, fig. 6.

- 1921 *Nummulites* cf. *pengaronensis* Verbeek; Yabe, pp. 104, 105, pl. 18, fig. 8.
 1929 *Nummulites pengaronensis* Verbeek; Vlerk, pp. 20, 21, figs. 12, 35a, b.
 1932 *Camerina pengaronensis* (Verbeek); Doornink, pp. 283, 284, pl. 4, figs. 1-3; pl. 6, fig. 12.
 1934 *Camerina pengaronensis* (Verbeek); Henrici, pp. 29, 30, pl. 1, fig. 10.
 1934 *Camerina* cf. *pengaronensis* (Verbeek); Caudri, p. 52.
 1953 *Camerina saipanensis* Cole, pp. 20, 21, pl. 2, figs. 7-19.
 1957 *Camerina pengaronensis* (Verbeek); Cole, pp. 753, 754, pl. 231, figs. 1-17.
 1959a *Nummulites pengaronensis* Verbeek; Nagappa, pp. 163, 166, pl. 10, figs. 3-5.
 1965 *Nummulites* cf. *saipanensis* (Cole); Adams, p. 313, pl. 23, fig. c.

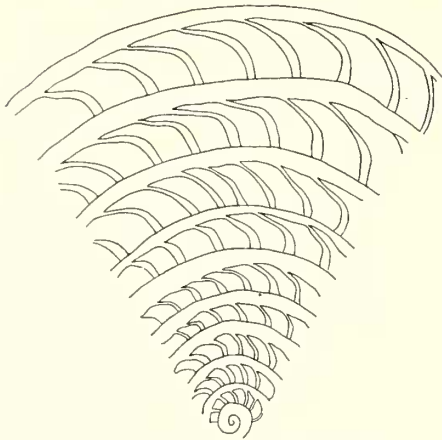


TEXT-FIG. 5. *Nummulites pengaronensis* Verbeek (megalospheric form). A-C, Axial sections, $\times 25$ approx.; A, from locality Sa; B, from locality K; C, from locality N. D, Split specimen from locality Sa, $\times 20$ approx. E, Equatorial section from locality Rn, $\times 25$ approx.

Material. Megalospheric form—75 specimens examined externally, 5 studied in equatorial section, and 12 in axial section. Microspheric form—12 specimens examined externally, 3 studied in equatorial section, and 4 in axial section. In addition, 23 split specimens of megalospheric form and 3 of microspheric form were studied in equatorial view.

Description. Megalospheric form. Test small, compressed, lenticular to globose, with acute margin. Surface marked by thin, radial septal filaments, straight to gently curved at ends. Diameter of test varies from 2.0 to 5.2 mm., thickness from 0.8 to 3.3 mm., and ratio of diameter to thickness from 1.3 to 3.6.

Spire more or less regular with about 5 to 7 whorls increasing regularly in height, with exception of last whorl, which may be narrower than preceding one. Height of spiral cavity in outer whorls about 3 times thickness of spiral lamina. Septa nearly perpendicular to inclined at their base, straight for about half their course, then curve sharply backwards. Thickness of septa decreases considerably from proximal to distal end. About 6–7 septa occur in 1st whorl; 11–14 in 2nd; 17–19 in 3rd; 23–6 in 4th; 24–7 in 5th; 26–9 in 6th; and 29–32 in 7th.



TEXT-FIG. 6. *Nummulites pengaronensis* Verbeek. Part of the equatorial section of a microspheric specimen from locality Sa, $\times 18$ approx.

First chamber circular to elliptical in equatorial section, followed by usually smaller, crescentic to reniform second chamber. Separating wall curved outwards. Diameters of first chamber vary from 0.125×0.120 mm. to 0.275×0.225 mm., those of second chamber from 0.105×0.050 mm. to 0.175×0.075 mm. Distance across both chambers varies from 0.200 to 0.325 mm. Equatorial chambers subquadrate to falciform in shape, usually higher than long, although reverse also quite common.

In axial section first chamber circular, about 0.100 to 0.175 mm. in height. Alar prolongations extremely narrow. Appreciable reduction in thickness of spiral lamina at periphery. Marginal cord distinct. Traces of weakly developed pillar-like structures in polar region.

Microspheric form. Test small- to medium-sized, lenticular, with acute margin. Septal filaments radial, straight. Diameter of test varies from 4.6 to 8.9 mm., thickness from 1.9 to 3.3 mm., and ratio of diameter to thickness from 2.0 to 3.3.

In equatorial section about 9 to 13 whorls occur, regularly increasing in height. Height of spiral cavity greater than thickness of spiral lamina. Septa nearly perpendicular at base, straight for about half their course, then curve sharply backwards. Thickness of septa decreases considerably from proximal to distal end. Chambers subquadrate to falciform, usually higher than long.

In axial section chamber cavity triangular in shape. Alar prolongations extremely narrow. Considerable reduction in thickness of spiral lamina at periphery. Marginal cord weakly developed. In polar region traces of pillar-like structures.

Remarks. Although the Assam specimens show considerable variation in external form